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The authors of papers and articles are requested to scrutinize carefully the typed or cyclostyled copies before forwarding them. Equations and formulæ are best inserted in hand. Two sets of drawings should accompany an article. One set should be mere line-work without any lettering and the other complete with lettering, the former preferably on tracing cloth. Colour wash or line and pencil shades cannot be reproduced in line blocks. They should be replaced by hatching, and colour lines by dashed chain or thicker black lines. The size of drawings or line blocks should generally be double the size to be reproduced in print.

It is desirable that the use of the first person should be avoided. When a specific statement is to be made, it should be written : " The author submits . . . . ", " The author holds the opinion . . . . . ", etc. It is desirable that articles or papers should be sectionalized by giving suitable ' sectional headings '. Avoid long and involved sentences ; short sentences are more effective and less likely to be misinterpreted. Do not begin a new sentence with a numeral, write the number in full as word. Place zero before the decimal point, when the figure represents something less than unity; thus : 0·75. Place a comma to mark the thousands in number of four figures and more ; thus : 2,127,356, and, in the case of Rs. thus : 27,26,127. Do not write in the text of the article 8′ 6″ by 4′ 3″ but as 8 feet 6 inches by 4 feet 3 inches or as 8·5 feet by 4·25 feet. For numbers under 10—write out in full, if not followed by an abbreviation ; thus, write nine days, but 9 lb., not nine lb. For numbers over ten use numerals.

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Radio Telephone for the Central Break Down Organisation of the Madras City Distribution.

By S. KRISHNASWAMY, B.Sc., C.I., I.Sc.,
Divisional Engineer (Electrical)

Introduction.—Communication is an important aid for any breakdown organization of a power undertaking for rendering prompt service. In the City of Madras with 1,000 miles of H.T. and L.T. mains (mostly underground cables) and with 52,000 H.T. and L.T. consumers giving rise to nearly 25,000 calls per year, the task of the breakdown organization is indeed very onerous. The object of this article is to outline the extent to which the radio telephone system which is proposed to be introduced in Madras for the breakdown service before the end of this year will be useful in this task and also give an idea of the fundamental principles of the Very High Frequency (V.H.F.) Communication and the salient features of the equipment ordered of Messrs. Pye Telecommunication, Limited, for this purpose.

2. *Function of Breakdown Service.*—The function of the breakdown service is to promptly restore supply to the affected areas and also attend to the fuse off calls of individual consumers. The breakdown gang replace blown out fuses at transformer structures, feeder pillars, etc., isolate faulty section, give alternate temporary supply for the affected area to the extent possible and notify the territorial staff to take over the faulty section for rectification and restoration of normal supply as quickly as possible.

At the time, the Madras Electric Supply Corporation was taken over by Government in August 1947, a central breakdown organization was functioning, manned by an inspector-in-charge of a cable jointing gang, linemen, fusemen, an automobile van, etc. There were also a few fuse off call centres at the sub-stations to function during evening peak load periods.

Though this arrangement was satisfactory at the time, when the underground system was limited and consumers were barely 22,000, they were found no longer adequate to meet the increasing mileage of mains and number of consumers.

Even now, the centralized organization is being continued with the central breakdown bunk located at No. 157, Mount Road, Madras, and receives all calls of supply failure and attends to the

breakdown of mains and the fuse-off calls in the nearby area. Also five more mobile subsidiary centres at Mylapore, Mambalam, China Bazaar, Kilpauk and Thondiarpet have been opened functioning for 8 to 16 hours a day. Additional fuse off call centres have also been opened at sub-stations, where phone facilities are available to function during peak load periods.

Even so, these arrangements at present are found inadequate to deal with the numerous daily breakdown calls and which sometimes mount up to more than 550 during stormy days.

On the basis of one fuse man for every 1,000 services and a fuse off call centre not exceeding a cycling distance of ¾ mile it is estimated that 20 centres and adequate number of fusemen will be required to function in the evening hours and about half that number will have to function in the mornings also.

3. *Existing communication system.*—At present all the calls of supply failure are received by the C.B.D. which is provided with a P. and T. phone. After office hours one more phone is made available to the Bunk. The existing fuse off call centres are at sub-stations, where phones installed for operation purposes are used for relaying the fuse off calls from the C.B.D.

The present communication system has the following drawbacks:—

(1) During bad weather when the power system is affected, the telephone system may also sometimes be affected which is likely to paralyse the breakdown service.

(2) Though two phones are available at the C.B.D. during out-of-office hours they are inadequate for receiving calls and transmitting them to the fuse off call stations. This invariably results in the phones getting continuously engaged causing considerable delay in receipt and transmission of calls.

(3) The phones at the fuse off call centres also sometimes get engaged by consumers' direct calls thereby causing delay in the relaying of calls from the C.B.D.

In line with the arrangement in some of the other cities in India like Calcutta, the following proposals for overcoming the last two difficulties mentioned above were under active consideration.

They were—

(1) to provide for two more additional lines and phones for the C.B.D. to receive the incoming calls, and

(2) to have a separate extension telephone system from the C.B.D. to each of the 20 fuse off call stations so that these stations are readily available for relaying the public calls. Further, this will prevent the public from directly contacting these stations so that the breakdown organization may effectively function on a centralized system.

Though the use of P. and T. phones is inevitable for the incoming calls still the above scheme was found to suffer from disadvantages mentioned below:—

(1) Dependence on P. and T. telephone system.

(2) Too many telephone centres.

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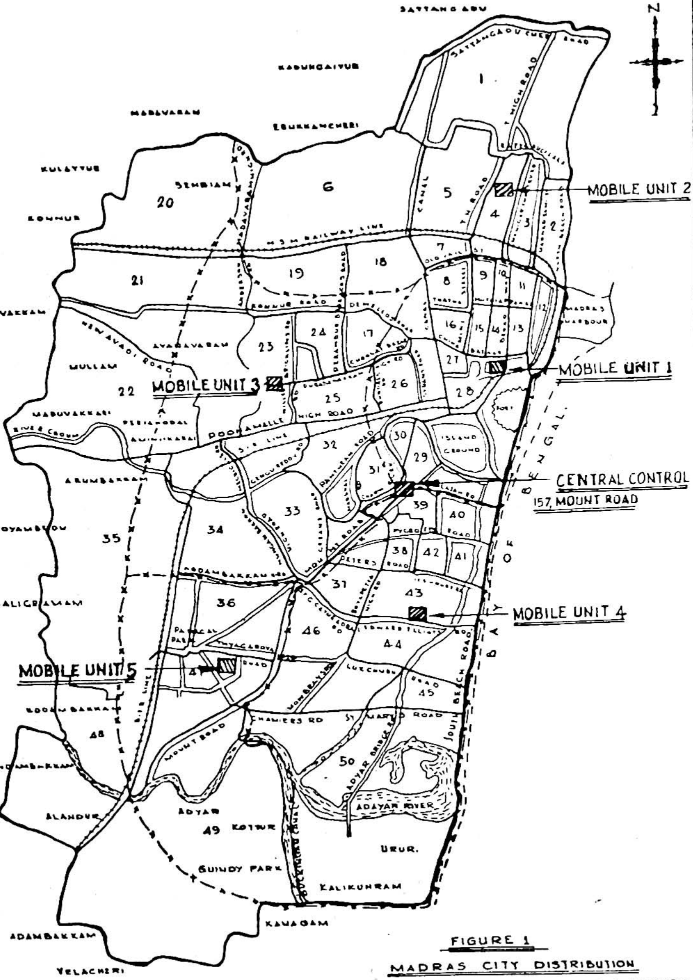


FIGURE 1

MADRAS CITY DISTRIBUTION

RADIO TELEPHONE FOR BREAKDOWN SERVICE

(3) Hugs staff consisting of 165 men and 9 telephone operators. It was, therefore, decided to introduce the modern mobile radio telephone system for the breakdown service in the city as adopted by power undertakings in Western Countries.

4. *Advantages of Mobile Radio Telephone.*—During the Second World War the mobile radio telephone was considerably developed and perfected. At present this is being adopted on a large scale by power undertakings for breakdown service, by civil engineers in project constructions and in surveys, by railways, police, ambulance, fire fighting, snow clearance, docks, hire cars, tugs and many other undertakings. In India, this is already in use by the police in the City of Madras, Calcutta and Bombay and our Department will be the first in introducing the same for electricity breakdown work in a city.

By installing one fixed station at the C.B.D. and having five mobile units deployed as indicated in the adjoining Fig. 1 the entire city area can be covered.

In this scheme, the calls from the public will be received over P. and T. phone and relayed to the mobile units over the radio telephone. This will in effect convert the existing five subsidiary mobile breakdown units and the proposed 20 telephone-*cum*-fuse off call centres to one of five mobile units equipped with radio telephones. Not only the number of men required for the breakdown organization can be reduced from 165 to 72 but also considerable petrol will be saved as the mobile unit in the area will be directed by the C.B.D. from one place to another, as the calls from the public come in, without its returning to its centre to receive the next call. Further this will enable rendering speedy service for the following reasons:—

(1) The P. and T. telephones at C.B.D. are no longer engaged for relaying the calls to fuse off call centres and they are fully available to receive incoming calls from the public without hold up.

(2) The time taken by the breakdown van to return to its centre after attending to each call is now saved.

(3) With the availability of communication to the crew attending to the breakdown, effective direction in executing the work can be given by the C.B.D. and also additional assistance diverted from other centres too if required.

5. *Fundamental Principles of V.H.F. Communication--Nature of Propogation.*—In the mobile radio telephone, ultra short wave (10—1 metre) of the frequency range 30 to 300 Mc/s is employed. In the short wave propagation the waves travel along the ground and also get refracted by the "Kennelly-Heaviside layer" of ionized atmosphere and combine to give the signal strength. At great distance, however, the ground wave is absent because of attenuation and the signal strength is mainly from the refracted wave. As the frequency increases the degree of refraction in

the ionized layer becomes progressively less until at frequencies of 60 Mc/s and above the sky wave seldom if ever appears again. The propagation is entirely in terms of ground wave and is, therefore, restricted to that of optical or line of sight range.

The signal strength from a half wave dipole antenna being

$$E = \frac{88 \sqrt{w\ ah}}{\gamma\ \gamma^2} \text{ volts per meter,}$$

Where w = the radiated power in watts.

a = receiving antenna height

h = transmitting antenna height

r = distance of separation between the two

γ (jame) = operating wave length all expressed in metres.

The field radiated by a transmitting antenna depends greatly upon the ground conductivity in the immediate vicinity of the radiator.

The actual range, therefore, depends on the height of the antenna and nature of the intervening country. Over sea or completely flat country it is about 25 per cent greater than the optical or line of sight range. The actual range obtainable in hilly countries or in heavily built up area is less because of absorption. The higher the frequency the greater is the reduction of range by such obstacles. On the other hand, the appreciable amount of noise interference from electrical machineries, ignition system of cars, etc., normally found in a city decreases as the frequency is increased. From practical experience the best frequency is about 80 Mc/s or say between 70 and 100 Mc/s.

In an actual test with a 50 watt fixed station at No. 157, Mount Road, using 60 feet antenna and 2·5 watt mobile set the range, that could be obtained in the Madras City was found to be of the order of 8 to 10 miles.

As this is only a short distance communication, which does not interfere with radio broadcasting, frequencies in the band from 60 to 184 Mc/s are allocated by the authorities all over the world for this purpose.

6. *Type of Service—Simplex and Duplex.*—In the Simplex System a single frequency is employed both for the transmitter and the receiver, while in the Duplex System different frequencies are used for Transmitter and Receiver.

This means that with Simplex System only one operator can speak at a time, and when he transmits, his receiver is automatically switched off and he cannot hear if the other transmits to him. This is shown in Fig. 2. With the Duplex System, however, both the receiver and transmitter function simultaneously and conversation can be conducted as in an ordinary telephone. In the case of Simplex System, therefore, the users require

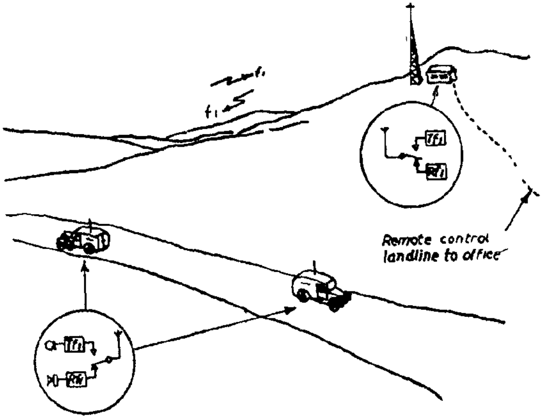


Fig. 2—Single frequency Simplex System.

some practice and discipline. This system is, however, widely used as it has several advantages, viz.:—

(1) There is conservation of frequencies.

(2) As the frequency is common to all units each unit can hear all others and common command can be communicated to all simultaneously.

(3) The mobile sets can intercommunicate without passing through the fixed station.

(4) Power consumption is less as only the receiver is on when the transmitter is not working.

(5) Unnecessary conversation is not possible.

The disadvantage is that such a system cannot be coupled to the telephone system, as is possible in the case of Duplex System.

The other difficulty of the inability of two mobile units to communicate one with another directly is overcome by adopting two frequency Simplex System as shown in Fig. 3.

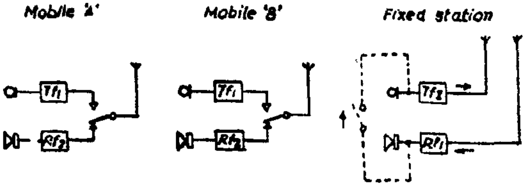


Fig. 3—Two frequency Simplex re-transmission.

In this the transmitter frequency of the mobile set is f1 and the receiving frequency is f2, while for the fixed set the transmitting frequency is f2 and receiving frequency f1. By closing the talk through switch at the fixed station the transmission from mobile set No. 1 is received on frequency f1 and retransmitted on frequency f2 to the mobile set 2. For the Madras Breakdown Service, Simplex System is considered adequate and has been adopted.

7. *Modulation.*—The principle of modulation of the V.H.F. wave by the speech wave is exactly similar to any other carrier wave. The readers are requested to refer to the author's article on Carrier Current Communication in Madras Grid appearing in April to June 1955 issue of the Departmental journal, wherein this subject has been dealt with at some length. For the reasons stated therein, it has been decided to go in for Amplitude Modulation.

8. *Transmitter—Receiver.*—The A.M. transmitter will comprise of a crystal oscillator to control the frequency and a number of stages of frequency multiplication followed by a power output stage. The multipliers consist of simple tuned amplifying stages in which the output circuit is tuned to a multiple of the input circuit frequency. It also contains an audio amplifier to raise the level from the microphone and a modulator.

The super-hetrodyne receiver is generally of a double super-het type. The incoming signals are usually passed through at least one stage of radio frequency amplification before being mixed with the local oscillator output. This is obtained by multiplying the frequency of a quartz crystal. The resulting intermediate frequency is amplified and mixed once more with a lower frequency obtained from the same crystal oscillator. The second intermediate frequency thus obtained is then amplified and passed to the demodulator, where interference limiters are placed in the circuit.

Interference is one of two types—random and impulsive. The random noise which is continuous in character and is caused by electric motors certain type of electro-medical equipment, etc., have to be suppressed only at its source and not at the receiver. The impulsive noise, which is of intermittent character caused chiefly by the ignition system of petrol engine and by electrical switch gear are eliminated by the interference limiters, by means of biased diode clipper leaving the steady signal practically unaffected.

The receiver is also provided with an efficient automatic volume control, which will hold the audio output sensibly constant over a wide range of input signal variation, arising from the mobile transmitter moving amongst trees and buildings.

In the case of mobile unit, arrangements are generally made to allow the modulator to be used as a public address amplifier in conjunction with a hailer loud speaker, which is useful to give instructions to the crew working nearby.

9. *Power Supply.*—In the case of fixed sets the power supply unit is of the conventional type for mains operation requiring automobile change-over unit and a battery operated motor generator set. In the case of mobile unit the H.V. supply is derived either from vibrator or a small motor generator worked from a 12 volt battery.

The power consumption of a mobile unit is about 14 amps in 'transmit' condition and 4·5 amps in the 'receive' condition for a bigger unit and 4 amps for 'transmit' and 3 amps for 'receive' for a smaller unit. As the 'transmit' time is very small compared with the time the receiver is on, there will not be much drain on the battery and they can be replaced once a day.

10. *Antenna.*—In order to obtain maximum coverage in all directions from a fixed station an omni-directional aerial system is usually employed. Though directional aerials could also be used to concentrate the radiation in a certain direction, it may result in an improvement in service rather than in range.

The aerial system is connected to the equipment by a screened co-axial cable which is usually polythene insulated. It is of course possible to use one aerial simultaneously for transmitting and receiving provided the frequencies are sufficiently spaced and the requisite filters are used. In the case of the set operating in conjunction with a telephone line it is essential that it should be properly matched—that is, it should have the same characteristic impendance as the set to minimise the losses.

11. *Siting of Fixed Stations.*—The siting of the fixed station must be carefully decided bearing in mind the coverage area required, the suitability and availability of sets, the control land lines or radio links, power supplies and accessibility. It is invariably best to choose the highest possible site in order to avoid the high cost of tall masts and it is also necessary to ensure that the site is remote as far as possible from sources of interference such as passing vehicles having unsuppressed ignition system. In the case of sub-station sites the antenna can be attached to the transmission line tower as the H.V. conductors normally cause very little interference at very high frequencies.

In the case of mobile unit, the vehicle ignition system, dynamo, wind screen wiper, etc., will need to be properly suppressed to avoid interference with the mobile receiver. Adequate attention should be given to see that all rubbing parts, viz., bonnets, boot covers, etc., are properly bonded with flexible copper braid. The standard resistors supplied for television interference suppression will usually be found adequate for use on the ignition system.

12. *Technical Specification of the V.H.F. sets ordered.*—For the V.H.F. Scheme proposed for the breakdown services, initially there will be one 50 watt fixed station at No. 157, Mount Road, and five 2·5

watt mobile units. One of the 2·5 watt sets will be used as spare both for the fixed and mobile stations. The sets are expected to cost Rs. 20,000 along with the spares for two years' operation.

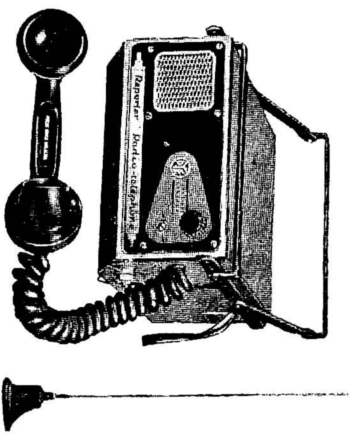
The specification for the sets ordered of Pye Telecommunication Company is briefly described below.

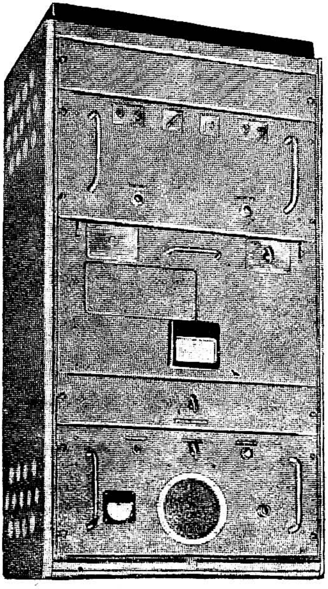
13. 50 *watt A.M. V.H.F. Fixed Station PTC* 750/1.—The equipment shown in Fig. 4 comprises of three units as under:—

(1) Receiver,

(2) 50 watt transmitter R.F. and modulator unit, and

(3) Transmitter power supply.





The equipment can be operated over a single pair of telephone lines of PYE PTC 411–407 Remote Control System, from a distance up to 15 miles and space is available in the standard cabinet to mount the requisite panel. Extension control allows control of the equipment from positions up to 200 feet from the station.

The transmitter is crystal controlled on all ranges, the crystal frequency multiplication being six times the frequencies below 100 Mc/s and 12 times the frequencies above 100 Mc/s. The provision of calibrated knobs, which are concealed in use on all tuning controls, and of a switched meter which can be connected to any stage in the transmitter enables easy and rapid adjustment of the transmitter to be made.

Sufficient audio gain is provided in the modulator to allow a moving coil microphone to be used locally while two further inputs are provided for connexion to either Remote Control System or to a high quality line input for broadcast transmission.

The transmitter is capable of continuous operation with 100 per cent speech or music modulation. Continuous tone modulation at 100 per cent level is not, however, possible. The transmitter is supplied for operation with a 72 ohm. coaxial feeder line.

The receiver is a 14 valve double superhetrodyne receiver and is fitted with a crystal controlled oscillator, a noise compensated muting system and an effective noise limiter. It is of high sensitivity and alternative I.F. pass bands and audio frequency response bands can be provided.

14. 2·5 *watt 'Reporter' set.*—This is a compact set, light in weight and with an extremely low power consumption as shown in Fig. 5. The transmitter and receiver are designed as a single unit housed in a rugged metal cabinet. The controls are kept to a minimum and are conveniently located for ease of operation. This set has the advantage that it can be operated both on 12 volt battery and 230 volts mains. Whenever the mobile unit is not functioning, the set can be operated at the substation using the mains and thereby conserving the battery.

15. *Technical Data.*—

	50 watt fixed set.	2·5 watt set.
Transmitter—		
(1) R.F. Output	50 watts	2·5 watt at 6, 1 watt 185.
(2) Frequency Range	60–185 Mc/s.	60–100 Mc/s PTC. 100–185 Mc/s PTC.
(3) Crystal frequency	....	In the band 8·8–16·6 Mc/s.
(4) Crystal frequency tolerance.	....	·003 per cent.
(5) Speech Modulator Capacity.	100 per cent.	95 per cent.
(6) A.F. Response	— 3 db at 300 5,000 c.p.s. for inputs at 0·1 mw. terminals or the microphone jack. ± 1 db. from 100-12,000 c.p.s. for input to the 2·5 mw terminals.	± 2 db. from 100-3,000 c.p.s.
(7) Power supply	230 volts A.C.	12 volts D.C. or 220 volts A.C.
(8) Power Consumption ..	Stand by 142 VA ..	36 VA.
	Carrier on 520 VA ..	42 VA.
	Transmit 585 VA ..	48 VA

	50 watt fixed set.	2·5 watt set.
Transmitter—*cont.*		
(9) Rating	Carrier continuous ..	100 per cent peak speech.
Receiver—		
(1) Sensitivity	Better than 1 micro volt.	Better than 2 micro volts for A.F. output of 50 mw.
(2) First intermediate frequency.	Crystal frequency ± 2·9 Mc/s.	± 2·9 Mc/s.
Second intermediate frequency.	2·9 Mc/s.	2·9 Mc/s.
(3) S/N Ratio	Better than 9 db. ..	Better than 8 db.
(4) Spurious responses ..	Atleast 55 db. down ..	
(5) Audio response	6 db. down at 200–2,000 c.p.s.	6 db. down at 150–1,800 c.p.s.
(6) Audio output	2·5 watt to loud speaker with independent 600 ohm. output at low power level for working into G.P.O. line.	1 watt into 3 ohm. loud speaker.
Total weight ..	....	17 lb.

Conclusion.—With the introduction of radio telephone, the Central Breakdown Organization in the city is expected to render speedy service. After gaining experience the radio phone could be introduced for other important cities as well. It will also find increasing application in the Department for purposes wherever saving of time is essential like issue of line clears. In case the distance is within a mile 100 milli watt radio phone called 'Walkie-Talkie' which works on dry battery weighing about 10 lb. could be used.

As the radio phone installation is not expensive in comparison with ordinary wire telephone, it may find increasing use in the Department in project works and in 33 K.V. sub-stations which are less than 10 to 15 miles apart.

High Speed Transverse Differential Earth Fault Protection for E.H.T. Parallel Feeders.

By V. CHANDRASEKARAN,
Assistant Engineer (Electrical).

Introduction.

The characteristics and settings of Impedance Time Relays were discussed in the Journal of the April-June 1955 issue by the Divisional Engineer (Electrical), Sri G. S. Rama Iyer. This article is written in continuation thereof and deals in particular with the salient features of the high speed transverse differential earth fault protection for the parallel feeders recently commissioned on the 110 KV lines of the Madras Grid. The routine pre-commissioning tests on the relays, their behaviour, due to incorrect inside connections and the methods that were adopted to detect and to rectify them, are also briefly dealt with.

The general principles of the differential protection will be first discussed very briefly. The differential protection of parallel feeders involves one high speed directional relay of type NSE-2 and one number differential relay of type 'DY' on each of the parallel feeders.

"DY" Relays

The differential relay balances the residual currents in its associated feeder against an average value for the whole group of feeders.

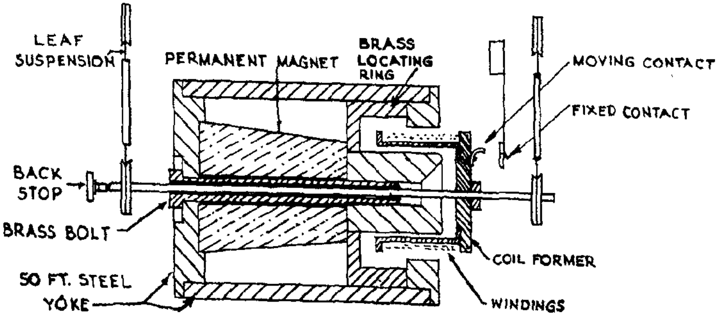


FIG.1.
DY RELAY

Two coils used respectively for operation and restraint within the relay are wound on a light weight aluminium former suspended horizontally between the concentric poles of a powerful permanent magnet. The shaft carrying the coil former is suspended by leaf springs. The coil former is longer than the pole width in order to give a constant operating force over the range of travel.

The coils are supplied direct current from rectifiers. Auxiliary transformers are also used since the relay is wound for a small operating current. The currents passing through the coils give rise to opposing forces. The operating force is derived from the residual current in one of the parallel feeders and the restraining force will be slightly greater than the average of the residual currents in the parallel feeders. A net restraint is thus applied when the residual currents in the two feeders are equal in magnitude.

NSE-2 *Relay.*—The directional relay is a single element induction relay comprising of one upper magnet which is energised by the residual voltage obtained from the open delta winding of the main voltage transformers and one lower magnet which is energised by the current flowing in the residual circuit of the main current transformers.

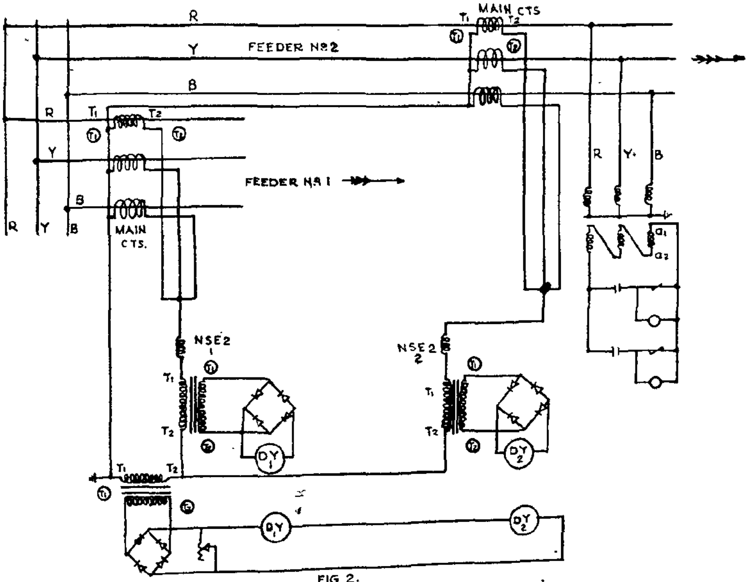


FIG 2.
CURRENT AND VOLTAGE CIRCUITS FOR DY & NSE2 RELAYS FOR TWO PARALLEL FEEDERS

The low power factor characteristic of fault conditions represents a phase angle of about 80° which would produce but a small torque. The torque is improved by a power factor compensator. A metrosil unit is incorporated to prevent excessive voltage rise. Its function is described below.

The operation of the DY parallel feeder (two feeders) DY protection relays is as follows:—

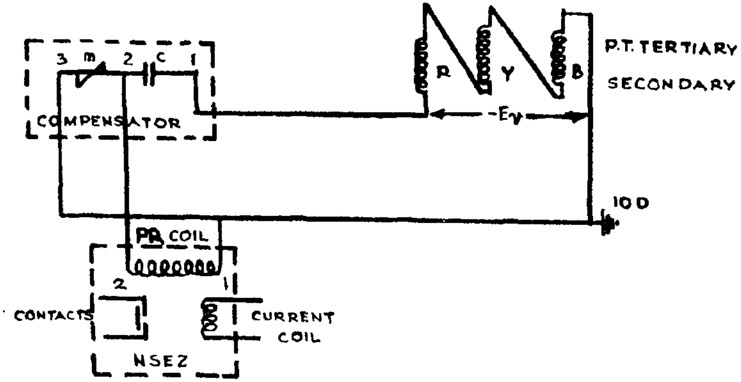


FIG. 3.—NSE₂ High Speed Directional Relay with powerfactor compensator.

The 'DY' relay operates as a true differential relay. The relay closes contacts when the current in the protected feeder exceeds the average current of the feeder group by a definite fraction.

At the receiving end, the fault current is flowing towards the local bus bars in the healthy feeder and away from them in the faulty feeder. The average current is therefore zero and the 'DY' relays on both feeders will operate and close their contacts.

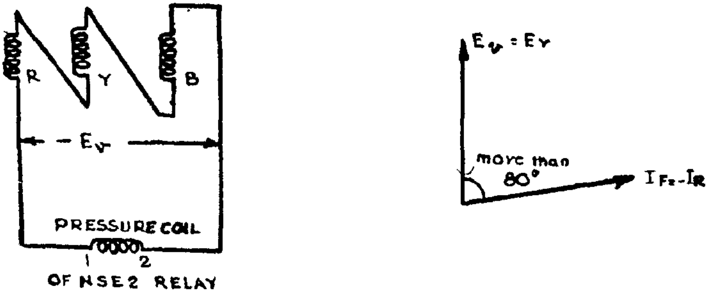


FIG. 4.—Standard Voltage Coil connection, when there is no compensator.

NOTE.—Connections of pressure coils of relay in Fig. 3 are reverse to those in Fig. 4.

At the transmitting end, the faulty phase of one feeder is carrying a fault current greater than the average for the two feeders and the corresponding phase of the other feeder is feeding the fault with a current less than the average. The 'DY' relay of the faulty feeder will alone operate as only the faulty feeder carries sufficient current to overcome the effect of the average current which is fed into the restraint coils of each relay.

The operation of NSE-2 high speed directional relay is as follows:—

The NSE-2 relay has a current coil energised by the current flowing in the residual circuit of the main current transformers and the pressure coil by the residual voltage obtained from an open delta tertiary winding of the main voltage transformer. A power factor compensator is used for the voltage coil in order to compensate the low power factor characteristic of fault conditions which may be of the order of about 80°. In addition to this improvement, the relay sensitivity is greatly increased at low residual voltages, although the combination is capable of withstanding the maximum residual voltage. This is achieved by using a metrosil unit (m) (as shown in Fig. 3) in parallel with the relay coil and a condenser in series with the combination. The metrosil unit contains silicon carbide and provides a resistance whose volt ampere characteristic is such that by doubling the voltage applied to it, the current can be increased twenty-fold, and trebling it, a hundred-fold. The action of the compensator is illustrated in Fig. 5A.

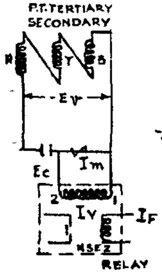


FIG.—5A.

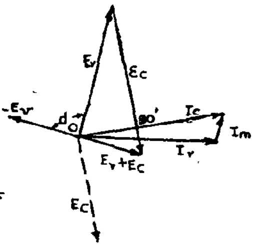


FIG.—5B.

For low value of residual voltage.

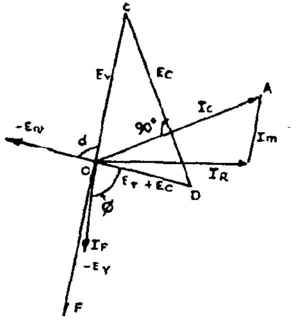


FIG.—5C.

For medium value of residual voltage.

NOTE.—
Er = relay coil voltage.
Ic = condenser current.
$Er+Ec$ = applied voltage.
Iv = current in relay potential coil.

If = fault current.
Im = metrosil current.
Ec = condenser voltage.
d = angle of compensation.
p = fault current phase angle.

Standard voltage coil connection when there is no compensator

The voltage coil connection is given in Fig. 4. The residual voltage E_v is applied direct to the relay pressure coil. The fault current If lags behind the voltage F_v rs shown above since the impedance of the fault is mostly reactive in the system, where the neutrals are solidly earthed. In this case, the angle between the relay coil voltage and the current I_h in the relay current coil is equal to the angle between the fault current I_f and voltage E_v. Hence the torque on the relay is very small.

The voltage coil connection when a compensator is used is given in Fig. 3. The vector diagram would be as follows.

Fig. 5 (*b*) is drawn to represent a low residual voltage and Fig. 5 (*c*) a medium value, the former being shown much enlarged. It will be seen that the primary difference between the two figures is the relatively greater magnitude of the metrosil current with consequent increase in the magnitude and rotation of the condenser voltage E_c. Although a low applied voltage is amplified by the resonance of the circuit, a high voltage does not produce a proportionately increased voltage across the coil.

The coil voltage E leads the input voltage (E_r plus E_c) . This is not suitable. The relay pressure coil connections are therefore reversed in polarity. The residual current If applied to the current coil in the relay lags more than 80° behind the input voltage vector E_r plus E_c Hence the reversed E_r in the pressure coil with the residual current I in the current coil of the relay gives highly improved torque to the relay disc in the proper direction. This reversal of the relay connections is equivalent to reversing the applied voltage vector. The angle between the reversed voltage vector Ev and the coil voltage vector E is called the angle of compensation.

Tests done to check operation of the impedance-time and the Differential Earth Fault Protection Relays

These relays have been installed in Pykara-Madras Grid, comprising of Pykara, Moyar, Erode, Mettur, Singarappet and Korattur Stations. These were tested by the concerned three M.R.T. subdivisions at Madras, Mettur and Coimbatore.

At Pykara and Moyar, fault simulating tests were done to check the sense of operation of the impedance-time and DY relays, as facilities for such tests were available in those places. Primary injection tests were also done. These tests proved that the original current connections to the impedance relays both at Moyar and Singara Power-houses were reversed, and the same was rectified and the sense of operation and association was confirmed by repetition of tests.

Fault simulating tests were conducted in May 1955 at Mettur and Erode to check the sense of operation of the impedance-time and differential earth fault relays on all the 110 KV feeders. The fault simulation was done by using one of the 110 KV buses at the station and feeding a simulated earth fault at the required location on the

feeders from one of the machines in the power-house at low voltage and excitation. This test could not be done at Singarappet as there were no alternative 110 KV buses at Singarappet.

All the C.Ts. on the 110 KV feeders at Erode, Singarappet and Mettur were found to have reverse polarity resulting in opposite sense of movement of disc in the relays in case of faults. The defects were rectified. Similar wrong connections were found on the 110 KV feeders at Pykara-Moyar and Basin Bridge. In Erode, Mettur and Singarappet, the connections on the auxiliary component box which supplied rectified current to the restraint coils of the DY relays were found reversed. The connections of the DY relays were rectified. These defects caused mal-operations in the grid.

One of the P.Ts. (110 KV/100 V) in Singarappet sub-station was having incorrect open delta leads connected to the NSE-2 relay potential coil. The same was set right. Similar kind of incorrect connections was found to have been made on both the 110 KV/110 V P.Ts. at Korattur. An easy method to check the correct operation of these relays was evolved as a result of these tests.

Checking of High Speed Directional Relay NSE-2 connections

The procedure to check up NSE-2 relay connexions is as follows:—

(1) Introduce the reversed 'B' current in the NSE-2 current coil by shorting 'B' phase C.T.

(2) Omit P.T. Secondary in 'R' phase and connect the open delta leads to 'Y' phase and 'B' phase secondary.

This represents approximately the fault condition.

The NSE-2 relay, if correctly connected, should operate in accordance with power flow. The relay connexions on the 110 KV feeders in all the stations in the grid were checked by the supplier's representative by adopting a different method, namely, disconnecting the primary of the R.P.T., connecting its line side to earth and checking the operation of the relay by charging the P.T. and shorting 'B' phase C.T. But this method happened to be tedious, and the easier method pointed out above had to be adopted for the checking of directional high speed relays at Moyar and Singara, for want of facilities to take out spare buses in these stations.

Checking of Differential Earth Fault Protection

The procedure to check up both NSE-2 and DY relays is as follows:—

(*a*) Remove trip supplied.

(*b*) Operate NSE-2 and DY relay of No. 1 feeder and see that auxiliary contactor AC-1 operates cutting out the corresponding DY (D.C.) circuit of No. 2 feeder. Check that the auxiliary contactor AC-2 cannot be made during this time to operate by closing NSE and DY of No. 2 feeder.

(*c*) Check as above operation of No. 2 feeder and non-operation of No. 1 feeder.

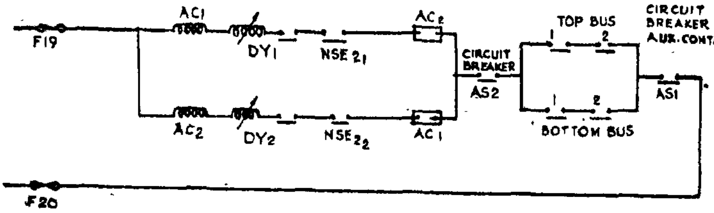


FIG. 6—D.C. Circuit for parallel feeder protection illustrating DY and NSE relay operation.

The general procedure, that was evolved to check the operation of the impedance-time relays in the grid is as follows:—

(1) Checking of current transformers—

(a) Remove D.C. supply in the concerned panel for a few minutes. Short out Y and B phase C.Ts. Check current flows in 'R' phase relays and DY relays.

(b) Repeat (a) for Y and B phase currents.

(2) Checking of potential transformers—

(a) Remove D.C. supplies. Check phase rotation at terminal board voltage fuses and at relays.

(b) Remove 'R' phase P.T. secondary fuse and check at relay panel; repeat for Y and B phase P.Ts.

(3) Checking of NZA-relay polarities—

(a) Operate R phase starting relay by hand and check for the correct operation of the 'R' element in accordance with power flow.

(b) Repeat for Y and B phases.

The above tests were found useful for a final check of connections on these types of relays by the testing staff, and the same are commended for general adoption. Such simple tests, enable checking of relay operation to be done within two hours at the most for each panel. More information is given by them than elaborate primary injection tests. A number of wrong connections in different stations in the grid, that were undetected in first commissioning, were revealed. This check is quite as good as fault simulating tests, is much simpler, and could be done without waiting for large shut-downs, and with only a few tripping operations for a few minutes.

Selection of High Pressure Steam Generating Plant

By S. VAIDYANATHAN, B.Sc., B.E.,
Assistant Engineer (Electrical).

INTRODUCTION.

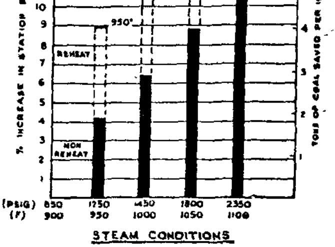
Steam-electric plants occupy a significant place in the generation of electric power. Improvements have been made rapidly in recent years and are typified by units of larger size, higher steam pressures and temperatures and the use of reheat cycle. To-day the largest plant sizes in U.S.A. range from 600 to over 1,000 MW of installed capacity with individual turbo-generators rated at 150 to 200 MW and boilers generating as much as 1,250,000 lb. of steam per hour. Typical steam conditions are 2,000 p.s.i. and 1,050°F with single stage of reheat. Such plants require about three-fourths of a pound of coal per kilo watt-hour.

The increase in station thermal efficiency and saving in fuel by adopting four typical initial steam conditions, with and without reheat, are shown in the chart below.

It is interesting to note that power plants which will operate with steam above the critical pressure are to be a reality. One such projected plant is the 325 MW super-critical turbine unit for the Eddystone station of the Philadelphia Electric Company, U.S.A., which will operate with steam conditions of 5,000 p.s.i. and 1,200°F with double reheat to 1,050°F. The expected heat rate is 8,400 B.Th.U. or about two-thirds of a pound of coal per net kilowatt-hour.

In any steam electric installation, about 50 per cent of the total cost is chargeable to the boiler plant equipment, boiler plant structure and associated miscellaneous equipments. There are several considerations to be taken into account in the selection of high pressure steam generating equipments. An attempt is made in this article to deal briefly with some of the major design requirements for a boiler unit and its component parts.

STATION EFFICIENCY IMPROVEMENT FOR HIGHER STEAM CONDITIONS AND REHEAT FROM 850 Psig. 900°F



Fuel Burning Equipment

The selection of firing equipment, design of the furnace and, in fact, the entire boiler unit is controlled by the fuel. Where a wide variety of fuels such as bituminous coals, lignite (raw, briquetted or char), etc., are to be burned with ease, the pulverised fuel equipment would be the obvious choice. The crushed coal is ground in the mills and the firing of coal as a fine powder through burners, gives quick and complete combustion of the fuel, with resultant heat transfer characteristics, superior to other methods of coal firing. Such an equipment possesses the following further advantages:—

(i) Can change rate of combustion quickly to meet varying loads.

(ii) Requires low percentage of excess air.

(iii) Reduces or eliminates banking losses.

(iv) can be repaired without cooling the unit down, since the equipment is located outside the furnace.

(v) Can easily be adopted to automatic combustion control.

(vi) Can utilize highly preheated air successfully.

Furnace

The design of the furnace should provide a combination of volume and water-wall cooling that will result in a furnace outlet temperature that is below the ash fusion temperature of the lowest quality fuel, that may be used. With coals having a high percentage of low fusion ash, it is necessary to have large furnace volume with correspondingly low heat liberation rates, so as to increase the amount of water-wall surface and thereby secure a comparatively low exit gas temperature. The rear wall of the furnace is usually brought forward in the upper part of the combustion chamber to obtain good mixing of flue gases leaving the chamber.

Superheater

The function of a superheater is to raise the saturation temperature of the boiler steam on its way to the turbine. This permits greater expansion of the steam before the moisture entrained becomes objectionable from the standpoint of erosion of the turbine blades. This results in greatly improved thermal efficiency of the steam cycle and some reduction of costs.

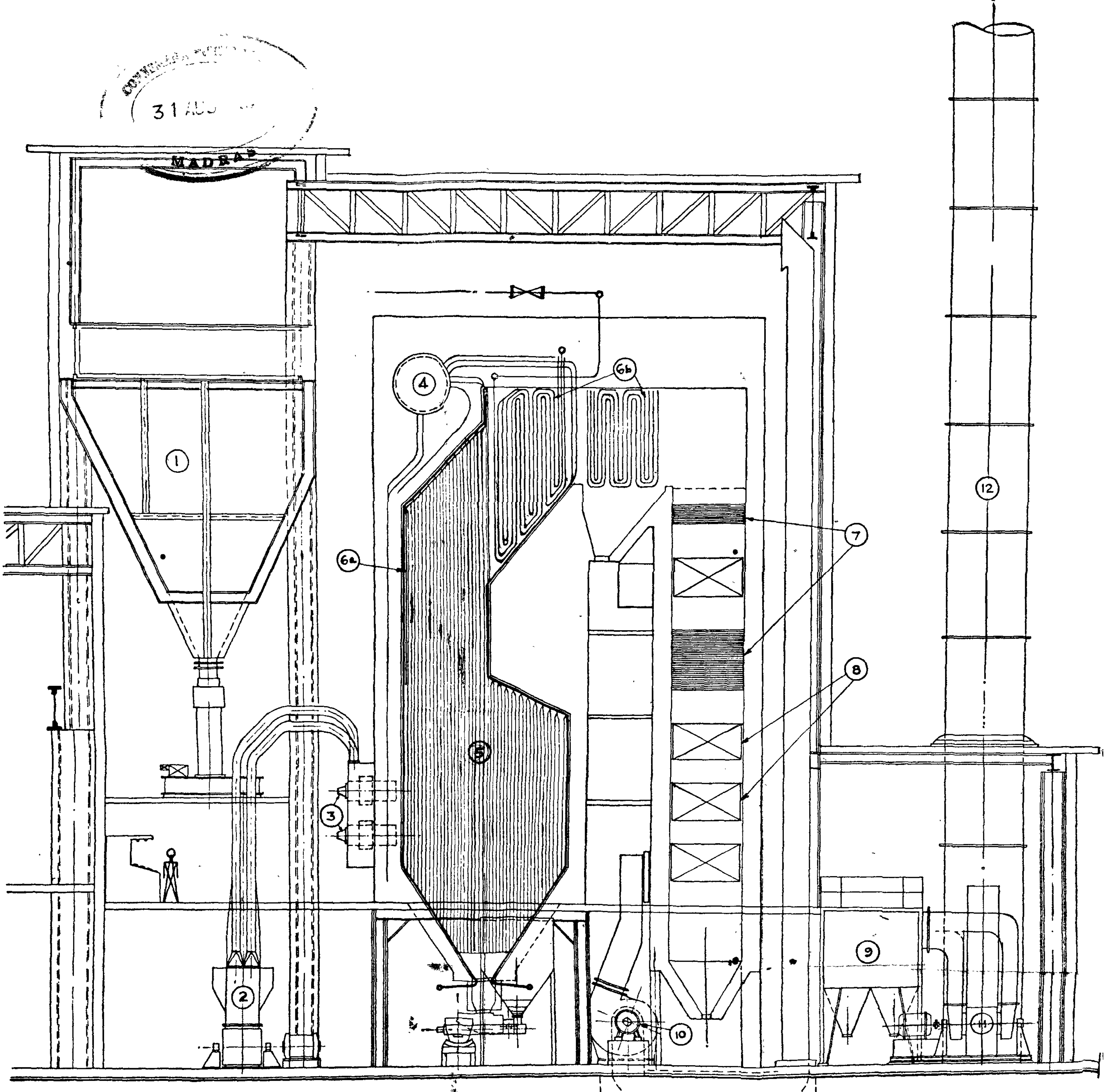
The radiant type super-heater absorbs heat by direct radiation from the furnace and is sometimes located in the furnace walls. It has a falling characteristic, i.e., the steam temperature drops as the steam flow rises.

The convection type super-heater absorbs heat chiefly by the direct impingement and flow of hot gases and the tubes. A purely convection type super-heater has a rising steam temperature characteristic.

It is advantageous to combine the above two opposing characteristics and to use a radiant type superheater in series with that of the convection type.

A means of obtaining super-heat control, is the gas ' by-pass damper control ', which varies the amount

31 AUG
MADRAS



RADIANT TYPE BOILER

FOR 150,000 LBS. OF STEAM PER HOUR AT 900 PSIG AND 925F

of the hot gases by-passed around the super-heater. This method is, however, not satisfactory, where load changes are frequent and of considerable magnitude, when there is apt to be some hunting to positioning the damper with resultant continual variation in final temperature. Another widely-used method is the division of the super-heater into primary and secondary stages and the use of an attemperator or de-super-heater, between the stages.

Economiser

The economiser utilizes heat in the flue gas that would otherwise be wasted, to heat the feed water to the saturation temperature of the water in the boiler. By its provision, better thermal efficiency for the plant results. In modern boiler units, the economiser is of the integral steaming type by which it is essentially an extension of the boiler heating surface in the last gas pass and designed to produce steam, when the unit is operating at high rates of output.

Air Heater

The air heater transfers heat from the flue gas as it leaves the economiser to the combustion air entering the furnace, with resultant fuel savings. Pre-heated air is essential when burning pulverised fuel, both to accelerate combustion and to dry the coal.

There are two general types of pre-heaters, the recuperative type and the regenerative type. The former includes the plate and tubular types.

Plate type pre-heaters comprise a series of thin plates with the gas and air passing counterflow, through alternate spaces. The use of this type is diminishing on account of difficulties in cleaning.

The tubular pre-heater consists of a series of tubes through which the gas passes with air over them in a counterflow direction. They can be cleaned mechanically or washed with water.

In the regenerative type, the elements are alternately brought into contact with the hot gases and the cold air. The heat taken up in the first half of the cycle is stored in the elements and given up in the second half. This principle is used in the '**Ljugstrom**' pre-heater which has a revolving spider within a circular housing. Hot gases pass up through one-half of the housing and cold air down through the other.

Dust Extractor

One of the serious problems with pulverised coal firing is the large percentage of carry-over of fly ash with the gases. An efficient method of dust extraction helps to minimise erosion of the induced draught fan ahead and results in increased boiler efficiency by reburning the combustible in the ash, where such a system is provided.

Mechanical 'multi-cyclone' type of extractors are in common use, while large installations would justify the use of electrical precipitators.

Mechanical Draught Equipment

It is the function of the draught producing equipment to supply the required amount of air to the furnace, to remove the products of combustion and to circulate them over the heat absorbing surface and finally to discharge them through the chimney to the atmosphere. Induced and forced draught fans should preferably be designed liberally to handle some excess volume to take care of operation with excess air, when required, and for poorer fan performance due to improper inlet conditions and worn, or dirty fan blades.

Control Equipment

A reliable system for automatically controlling firing rate, air and gas flow, steam temperature and feed water flow must be adopted. as that will do a better job than the human operator.

The automatic combustion control receives its primary impulse from steam pressure or steam flow. Any system that is selected should be simple and fool-proof.

Setting

The economy-minded engineer will insist that the setting of his new boiler is absolutely tight and will remain tight for many years of service. Air infiltration lowers boiler efficiency, increases fan power and may reduce steam output capacity.

A most practical setting enclosure is a completely welded and a strongly reinforced steel casing, which should be constructed to withstand furnace puffs that may occur during lighting-off.

Conclusion

In line with modern trends, the Department has decided to install two high pressure boiler units of capacity 150,000 lb. per hour each, for steam conditions of 900 p.s.i. and 925°F. for the III stage extensions to Basin Bridge. A sectional view of one of the boilers is shown in the plate enclosed.

These boilers are now in an advanced stage of erection at Basin Bridge Power Station. The boilers and the 30 MW Turboset are expected to go into service towards the end of 1957 at the above Station.

H.T. Meter Testing Kit.

By S. RAMAN, B.E. (Hons.),
Assistant Engineer (Electrical).

ONE H.T. METER TESTING KIT was recently rigged up at the Electrical Standards Laboratory. As this kit has certain special features, that are of general interest, a small description of it is given in the following article.

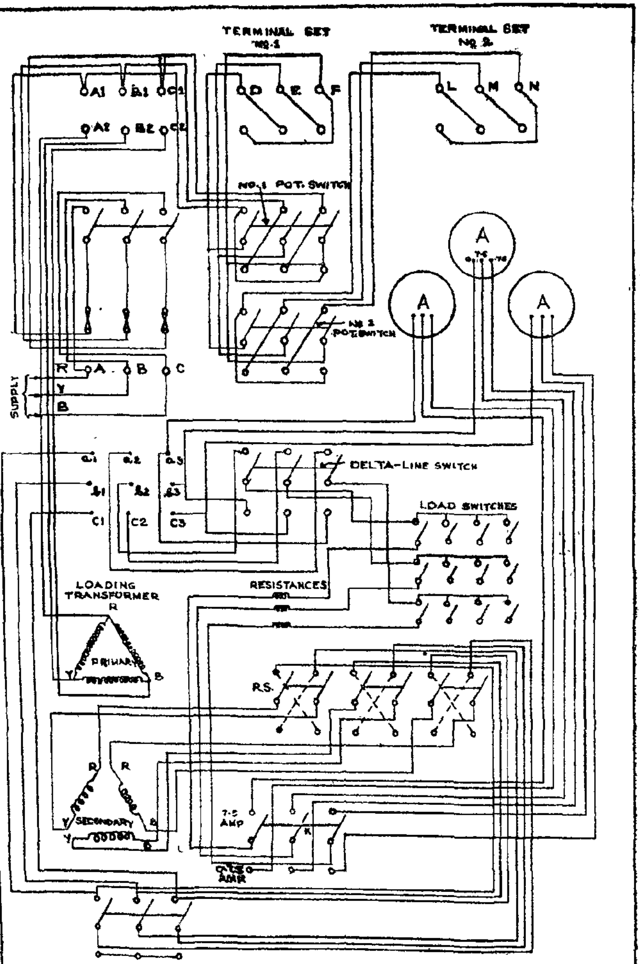
Requisites of a meter testing kit.—In a simple H.T. meter testing kit, the potential supply to the R.S.S. meter and the trivector meter under test, would be given directly from supply. Current supply to the series coils may be taken from the low voltage secondary sides of loading transformers, the primaries of which are connected to a centre-tapped delta connected transformer. A system of plugs and sockets enable any required supply being given to the loading transformers; and any power factor from zero lag to zero lead may be obtained at 30 degrees intervals. The load is generally controlled by coarse and fine rheostats included in the current circuits.

A somewhat elaborate kit would have a number of taps, provided on the delta transformer instead of the central taps alone, as in the case of a simple kit, thereby enabling control of supply to the loading transformers within 3 to 5 degrees of any required power factor. Chokes are included in the current circuits for finer control of load power factor. Load power factor of any value from zero lag to zero lead may be obtained on the kit.

Provision in the laboratory kit.—The kit rigged up at the laboratory is a simple one with three loading transformers connected in delta, direct to supply. There is no centre tapped delta transformer but the facility of a 30 degrees shift in power factor is obtained by connexion of the secondaries of loading transformers either in delta or in star. Where fine control of load power factor is considered necessary, a phase shifter is interposed between the mains, and the loading transformers; and any power factor from zero lead to zero lag may be obtained thereby quite easily and correctly.

Special features are provided on the kit, to facilitate a single 3-phase R.S.S. consisting of 3 elements of 110 volts: 1/5 amps. to be used to test the trivector meter, without any change of connexions to the meter and with the operation of a few switches only on the test kit.

Description of kit.—The supply is connected to terminals A, B, C of the kit. Through a triple pole control switch and control fuses supply is taken to terminals A_1, B_1, C_1. Terminals A_2, B_2, C_2 are connected to the delta connected loading



R.S - REVERSING SWITCHES.
K - AMMETER RANGE SWITCH.
A - AMMETERS.

H.T. METER TEST KIT

transformer terminals. By linking A_1 to A_2, B_1 to B_2, C_1 to C_2 supply gets directly connected to the loading transformers; or a 3-phase phase-shifter may be introduced between A_1 B_1 C_1 and A_2 B_2 C_2

The secondary supply is taken through a set of reversing switches and a star delta change over switch to current terminals a_1, b_1, c_1. There are two gaps on each phase, viz., No. 1 gapset of a_1 a_2, b_1 b_2, and c_1 c_2 and No. 2 gapset of a_2 a_3, b_2 b_3, c_2 c_3 for connecting the current coils of the meter. The loading arrangement is connected either across a_3 b_2, b_3 c_2, c_3 a_2 ; or between a_3 b_3, b_3 c_3, c_3 a_3 by operating a triple pole delta-line change over switch. In the former case No. 2 current gaps get delta currents, that is, currents taken by the delta connected loading rheostats. In the latter case, No. 2 current gaps get line currents, that are $\sqrt{3}$ times the delta currents in magnitude, and lagging the delta current by 30 degrees. Current gaps No. 1 always get line currents only.

One ammeter is included in each loading phase; and a range selection switch connects either the 7·5 amps range or the 0·75 amps range to the circuit.

There are two triple pole change-over switches provided on the potential side. Switch No. 1 connects the first set of potential terminals D, E, F, to the supply either in the order RYB or YBR depending on the switch being in top or bottom position. Switch No. 1 therefore helps to give supply to the terminals either direct supply from the mains or supply lagging mains supply by 120 degrees. Switch No. 2 connects to the second set of potential terminals LMN either the same supply as at DEF or supply FDE, that is, a supply leading by 120 degrees with respect to DEF, depending on the switch being in the top or bottom position. Both the sets of potential terminals are duplicated for easy connexions.

Procedure for testing trivector meters.—Assuming that a phase shifter is included in the circuit, the secondaries of the loading transformers would be connected either in star or in delta, as may be required for the load and the current reversing switches may be in either the top position or the bottom position. No. 1 potential change-over switch may be in top position, giving supply RYB to the potential terminals DEF. If the No. 2 potential change-over switch is in top position, supply given to the potential terminal LMN is RYB and if the bottom position, the supply given is BRY.

Testing of the trivector meter would be carried out as under.

Connections to the meter.—The potential and current connections of the R.S.S. meter and the trivector meter would be given as below:—

(1) Connect R.S.S. meter potential coils to DEF that is potential terminal set No. 1 and current coils to current gap No. 2.

Element.	*Voltage Supply.*	*Current connection.*
Red	RY	a_2 a_3
Yellow	YB	b_2 b_3
Blue	BR	c_2 c_3

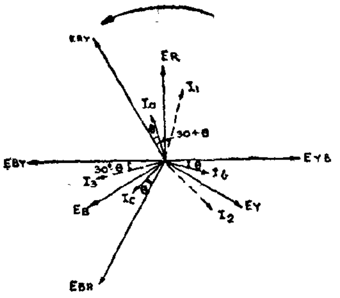


Fig. .1

(2) Connect trivector meter potential coils to No. 2 set of potential terminals and current coils to current gap No. 1.

Element.	*Voltage Supply.*	*Current connection.*
Red	RY	a_1 a_2
Blue	BY	c_1 c_2

Testing KWH meters.—Testing is proceeded with keeping the delta line switch in the delta position and the No. 2 potential changeover switch in top position.

The R.S.S. elements are connected to the line voltages and delta currents—vide Fig. 1. In the Fig. E_R, E_Y, E_B, are the star voltages, and E_{RY}, E_{YB}, E_{BR}, the line voltages of supply. I_a, I_b, I_c are the delta currents; and I_1, I_2, I_3 the line currents, making angle θ with the line voltages, and star voltages respectively. If E, I are the line voltages and line currents, the power in the circuit is $\sqrt{3}$ EI. Cos θ.

The R.S.S. Meter registers 3 × E × I_a Cos θ or $\sqrt{3}$ EI Cos θ; as $I_a = I/\sqrt{3}$. Therefore the meter registers the load correctly.

The KWH meter elements are connected to the line voltages RY, BY and line currents of Red and Blue phases, I_1, I_3. The meter register EI Cos $(30 + \theta)$ + EI Cos $(30 - \theta) = \sqrt{3}$ EI Cos θ. The meter registers the load correctly.

The R.S.S. meter and the KWH meter register the same load. It is, however, of interest to note that the currents, taken by the R.S.S. meter, being delta currents are only about 60 per cent of the line currents and as the ammeters on the kit are in series with the loading rheostats on each phase, the currents to be kept in the ammeters are only 60 per cent of the trivector meter currents required.

The load conditions of unity power factor and 0·5 lag power factor are obtained by operating the phase shifter.

Testing RKVAH meter.—Testing is proceeded with keeping the delta line switch in the line position and the No. 2 potential switch in the bottom position.

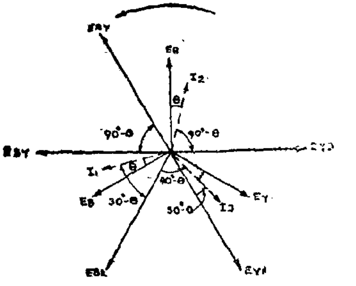


FIG. 2

The R.S.S. elements are connected to the three line voltages RY, YB, BR and the three line currents I_1, I_2, I_3—Vide Fig. 2.

The R.S.S. meter records 3 EI Sin θ that is $\sqrt{3}$ times the reactive power in the circuit.

The RKVAH meter elements are connected to the line voltage BR, YR and currents I_1. I_3. The meter records EI Cos. $(60-\theta)$—EI. Cos. $(60+\theta)$ or $\sqrt{3}$ EI.Sin θ. The meter registers reactive power is the circuit correctly.

The R.S.S. Meter therefore records $\sqrt{3}$ times as much as the RKVAH meter registration.

It is therefore possible to test both KWH and RKVAH meters of the trivector meter with the same R.S.S. by only operating the delta-line switch and the No. 2 potential switch on the kit. Also in both cases all the potential and current coils of the R.S.S. meter are utilized.

General.—It is possible to test the trivector meter, without the phase shifter, using the star delta change over switch, reversing switches, and the No. 1 potential switch.

The trivector meter can also be tested as usual using KWH, R.S.S. and RKVAH R.S. together.

It is also feasible to use the kit to test 3-phase 4-wire KWH meter up to 20 amps using 3-phase 4-wire R.S.S. This will be separately dealt with in due course.

Modifications to Pistol Type 'T' Cone-clamps used in Transposition Towers.

By C. K. RAMACHANDRAN, L.E.E.
Supervisor I Grade.

Conductor Snap at Transposition Tower.

There was a breakdown at Tanjore on one of the D.C. 66 K.V. lines owing to the snapping of a conductor at a point, where it was connected on to the aluminium rod jumper by means of a P.G. clamp. Being a transposition tower, aluminium rod jumpers had been used. The pistol type 'T' clamp used at present in E.H.T. transmission lines at transposition points, provide for cone clamping only of the conductor on the line side, the 'T' off portion of the cone clamp is left unused as the same would not take up the aluminium rod jumper. The use of aluminium rod as jumper has however been resorted to in order to obtain adequate phase and ground clearances while jumpering at transposition towers. Hence the rod jumpers are connected directly on to the conductor by means of P.G. clamp. Thus for any trouble developing in the P.G. clamps the line conductor is affected and this finally results in its snapping.

Special Clamping Device.

The simple and special clamping arrangements devised by the author for the pistol type 'T' cone clamp (see Fig. 5) to take aluminium rod jumpers would overcome this trouble, and could therefore be adopted for general use conveniently. The method adopted for specially clamping the rod jumpers to the 'T' off side of the cone clamp is described below.

The portion of the clamp assembly in the pistol type 'T' cone clamp, intended for the jumpers, which is left unused is taken out. The steel cone in it is set aside. Modifications as under are, then, carried out.

Fig. 1 shows the aluminium cone Z and the hexagonal nut Y of the clamp. These would have to be slightly filed at the place marked X to enable the aluminium jumper rod to just go through the clamp.

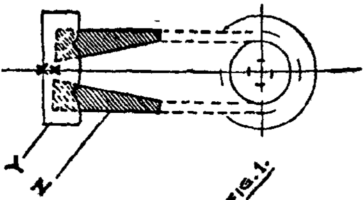


FIG. 1.

Fig. 2 shows the end of the jumper aluminium rod, which, at the place, where it has to go into the clamp, is cut into four equal parts to a depth of one and a half inches. The cut edges are suitably filed as shown and split in such a way as to take a conical aluminium wedge V.

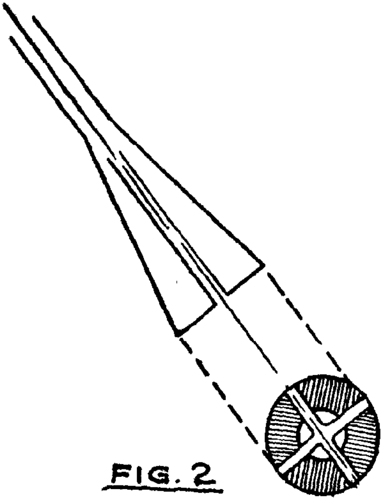


FIG. 2

A tapering cone is shaped out of another bit of a similar aluminium rod one and three-eighths inch long. This is shown in Fig. 3.

The narrow end of the cone is placed in the cavity obtained by splitting the cut end of the aluminium rod and pressed or driven such that it would just fit into the aluminium cone—*vide* Fig. 4.

The assembly then as a whole is inserted into the 'T' off portion of the pistol type 'T' cone clamp and the nut Y tightened up to secure the jumper properly. The final assembly is shown in Fig. 5.

Conclusion.

The snapping of conductor due to the use of P.G. clamps for aluminium rod jumpers at transmission towers can be prevented altogether by substituting with the pistol type 'T' cone clamp after the modifications, detailed above, are carried out.

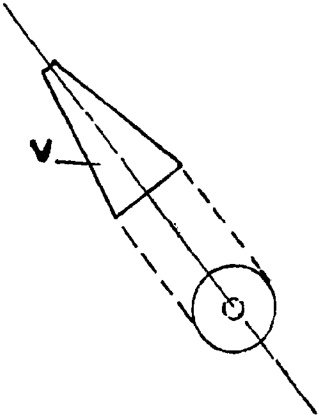


FIG. 3.

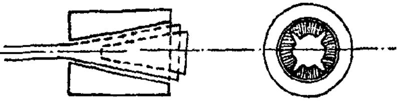


FIG. 4.

Remarks by Editor.

The aluminium jumper rods were in vogue years back, as it was then thought, that uniform jumpering was not possible with stranded conductors. Now the technique has very much improved and first-class work is possible with ordinary stranded A.C.S.R. conductors.

Even in the case of aluminium rod jumpers, a simple arrangement would be to use a stranded wire tail-piece in the pistol type grippers referred to by the author and in combination with P.G. clamps, the connection of aluminium rods on the tension side of the conductor can be avoided.

In modern practice we use compression type dead-end clamps with provision for taking of jumpers by means of A.C.S.R. conductors on the slack side only and the old method of connecting conductors on the tension side is completely avoided.

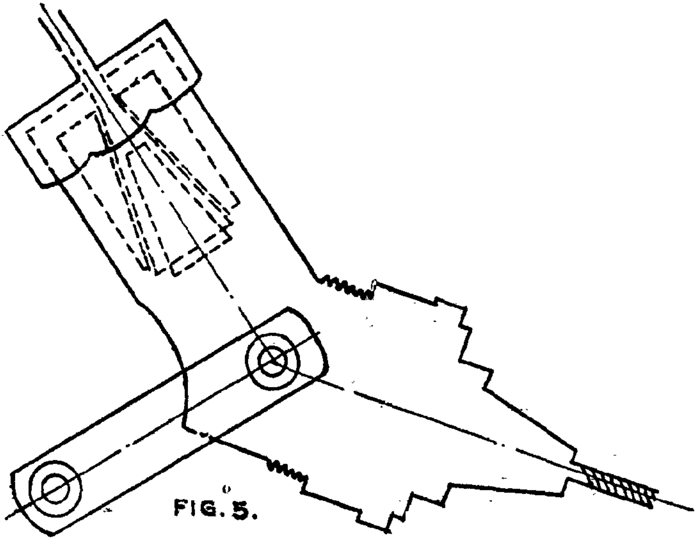


FIG. 5.

Progress During the Quarter Ending 31st December 1955

Salient Features.

The operation and maintenance of all the systems were satisfactory. In the Mukurthi and Pykara reservoirs, the inflow during the period was fairly good. In the Mettur reservoir, there was good inflow during the first half of the quarter but in the latter half, the inflow became poor and due to high irrigation draught storage position became unsatisfactory at the end of the quarter. In the Papanasam reservoir, too, the storage position was not satisfactory at the end of the quarter.

The Department earned a revenue of Rs. 171·35 lakhs during the quarter. The working expenses were during the quarter Rs. 71·86 lakhs. The capital expenditure was Rs. 265·71 lakhs, the increase being due to accelerated pace of construction works.

Supply was given to 1,846 agricultural services, 197 industrial services and 7,620 domestic services. The number of villages electrified during the quarter was 239. Three hundred and fifty-four miles of H.T. lines and 463 miles of L.T. lines were constructed and energized during the quarter.

Construction Branch.

Pykara Plant Extensions III Stage.—At the Pykara Dam, masonry works for all the three spillway spans and the first two piers were completed. The approach to the drainage gallery and parapet walls were also completed. Works on the earth bund were in progress. The construction of quarters at Mukurthy was progressing.

Madras Plant Extensions.—The repaired H.P. shaft of Turbine No. 1 of second stage, received from U.K., was put back and pre-commissioning tests were carried out on the turbo-set. The works relating to the mulsifyre equipment and air compressors were completed during the quarter.

Under the third stage, shifting of all equipments at " A " station to make room for the third stage works was completed. The dismantling of the concrete and the steel works of the " A " station continued progress. A total of 186 piles in the boiler house and 64 in the turbine room were driven for the foundation works.

Periyar Hydro-Electric Scheme.—Land acquisition for the project was in progress. Major portion of the roads in the project area was completed. Temporary buildings in upper and lower camps were completed and the permanent buildings were nearing completion.

In the forebay dam, excavation of foundation was nearing completion. The tunnel work and the sinking of

surge shaft were half complete during the period. Grading of penstock was in progress. Levelling of power house site and transformer yard was completed and excavation at power house site was progressing.

Contracts were awarded for turbines, generators and indoor switchgear power house, steel structures, penstock pipes and valves.

Transmission Lines—(1) *Salem-Nammakkal* 110 *K.V. line.*—The construction of the transmission line had been completed. The inspection bungalow at Salem was nearing completion. Construction of quarters, stores and telephone room at Rasipuram and Namakkal Sub-stations was progressing.

(2) *Singarappet-Villupuram* 110 *K.V. line.*—Excavation stub-setting, tower erection, stringing and painting were all completed in the Singarappet-Tiruvannamalai section and the works were under various stages of progress in the other sections. Erection of R.C.C. structures and construction of control room were in progress at Villupuram Sub-station.

(3) *Singarappet-Vellore* 66 *K.V. line.*—Check survey, tree clearance, excavation, stub-setting and concreting were all completed and the other works were under various stages of progress.

(4) *South Kanara Scheme.*—Hulikal-Mangalore 110 K.V. line, Udipi-Hariadka-Karkala 33 K.V. line and Udipi-Coondapur 33 K.V. line were all completed.

Construction of staff quarters and erection of switch-gear at all the sub-stations were in progress.

(5) *Villupuram-Pondicherry* 68 *K.V. line.*—Plotting of the route and preparation of tower schedules and profiles were completed.

(6) *Travancore-Cochin State Border-Udumalpet* 110/66 *K.V. D.C. line.*—Approval of the P.T.C.C. was obtained for the route and the survey works were in progress. Tenders have been called for the supply and erection of lines and sub-station.

(7) *Madukarai-Palghat* 66 *K.V. line.*—The fabrication of poles and structures was in progress; and erection works were commenced.

(2) *Periyar transmission lines.*—(i) *Periyar-Theni-Madurai* 110 *K.V. D.C. line.*—Survey work, plotting of profiles and preparation of tree valuation schedules were completed. Contract for supply and erection of the line was awarded to Messrs. S.A.E., Limited.

The construction of the quarters at Theni Sub-station was in progress and contract was awarded for the construction of office, store and control room.

(ii) *Theni-Sembatti* 110 *K.V. D.C. line.*—Approval of the route was obtained from P.T.C.C. and check survey was nearing completion.

(iii) *Sembatti-Tiruchirappalli* 110 *K.V. D.C. line.*—Approval of the route was obtained from P.T.C.C. and survey work was in progress.

(iv) *Sembatti-Karur* 66 *K.V. S.C. line.*—Survey work was in progress.

Operating Systems.

Hydro Systems.

The Station peak-load, Units generated and the System peak-load, were as follows:—

Name of System/Station.	*Station peak load in M.W.*	*Units generated in millions.*	*System peak load in M.W.*
Pykara	70·6	89·062	65·95
Moyar	36·2	38·247	
Mettur	41·2	70·826	63·15
Papanasam	28·0	26·612	27·20
Madurai Thermal station	10·5	3·516	..
Udipi	..	0·248	0·40

The following services were connected during the quarter:—

Name of system.	*Agriculture.*	*Industrial.*	*Domestic.*
Pykara System	952	44	2922·
Mettur System	490	34	1170.
Papanasam System	236	36	2038.

The Mukurthy reservoir remained full. About half of the storage at Pykara reservoir had to be used up on account of the defect in the discharge valve and scour pipe. The inflows at Mettur were fairly good, during October and the beginning of November, but thereafter the inflow was poor and the storage position was not satisfactory. The inflows in the Papanasam reservoir were not satisfactory except for a brief spell during the last week of November.

The annual overhaul of machines 1 and 7 at Pykara and 1 and 2 at Papanasam was completed during the quarter.

Erection of the three 4 M.V.A. transformers at Salem were nearing completion. Works in connection with the change over of the Erode-Salem line from 66 K.V. operation to 110 K.V. were in good progress.

Pykara System.—The 33 K.V. line from Cannanore to Badagara was completed and power supply eqected to Badagara at 11 K.V.

Works on the Somanur-Puliampatti 66 K.V. line were nearing completion and Puliampatti-Shembagapudur 33 K.V. extensions were in advanced stages of construction.

In the Ingur-Olapalayam 33 K.V. extensions 80 per cent of H.T. line works were completed and the sub-station works at Ingur and Ilapalayam were in good progress. One 1,000 K.V.A. transformer diverted from Cannanore was erected at Pykara and commissioned for supplying the municipal 11 K.V. loads.

The acquisition of the Mangalore Electrical Undertaking programmed for 15th December 1955 was postponed as per Government orders.

Mettur System.—The Arni-Vellore 66 K.V. line link was energized during the quarter. The three 1500 K.V.A. transformers were assembled and kept ready at Arni sub-station. The third 3000 K.V.A. transformer was erected at Karur.

During the quarter 364 tons of power and 844 tons of line materials were manufactured in the Mettur workshops, valued at Rs. 11 lakhs.

The East Ramnad licensee undertaking was acquired on 1st November 1955

Papanasam System.—Due to the heavy gale and rains caused by the cyclone in the last week of November 1955, the transmission and distribution lines to and around Sivaganga and at the East Ramanad licence area suffered heavy damage. Rectification works were put on hand and supply was resumed to the areas expeditiously.

The 33 K.V. equipments at Thalayathu Sub-station were tested and commissioned.

Erection of telephone equipments at Thalayathu, Sattankulam and Srivaikuntam Sub-stations was completed and the telephone line from Talayathu to Sattankulam was commissioned. The S.N. Koil-Tenkasi section of the telephone line on the Madura-Tirumangalam-Rajapalayam-Tenkasi extension was also commissioned into service.

Thermal Systems.

Madras System.—The Station peak load, Units generated and the System peak load wrere as follows:—

Name of System/Station.	*Station peak load in M.W.*	*Units generated in millions.*	*System peak load in M.W.*
Madras System	..	..	38·2
'A' Station	27	22·879	..
'B' Station	15	12·515	
	Total ..	35·394	

The following services were connected during the quarter:—

Agricultural—168.

Industrial—83.

Domestic—1,490.

The operation of the Stations was satisfactory. Boilers No. 1 and No. 4 were overhauled during the quarter. The repaired H.P. rotor of the T.A. set No. 1 was received at site and the T.A. set was commissioned into commercial service.

The Chingleput Electric Supply Corporation was acquired on 15th November 1955.

The Kancheepuram-Kadambathur 33 K.V. line was completed and energized. Major construction works involving the laying of 11 K.V. cables of various sizes were under various stages of progress. The erection of outdoor sub-station and switch-gear under the Madras Development plan in various sub-stations were in good progress.

Five hundred and eighty services with a connected load of 486 K.W. were changed over on a voluntary basis from D.C. to A.C.

Rural Electrification.

The number of villages electrified during the period under review in the various system were as follows:—

Pykara	89
Mettur	59
Papanasam	44
Madras	47
Total	239

The length of lines constructed and brought into beneficial use during the quarter under the various schemes of rural electrification were as follows:—

System.	*Length of line in miles.* H.T.	L.T.
Pykara	47·76	133·65
Mettur	196·05	160·76
Papanasam	59·96	104·88
Madras	50·27	63·92
Total	354·04	463·21

Accounts Branch.

The Department earned a revenue of Rs. 171·35 lakhs. The working expenses amounted to Rs. 71·86 lakhs.

The capital expenditure during the quarter (including suspense) amounted to Rs. 265·71 lakhs and the capital expenditure for the current year to the end of December 1955 amounted to Rs. 489·77 lakhs.

The following loan contributions have been received in the various systems to the end of October 1955:—

System.	*Rupees in lakhs.*
Pykara	11·00
Mettur	3·84
Papanasam	2·96
Madras	18·90
Total	36·70

Technical Branches.

(A) *Electrical Branch.*—Tenders received for the generating machinery and indoor switch-gear and sub-stations for the Periyar Hydro-Electric Scheme were analysed and orders placed. Orders were also placed for the supply of 10,000 tons of steel.

Tenders received for the Villupuram-Pondicherry 66 K.V. line and the Travancore-Cochin State border to Udamalpet 110/66 K.V. line were analysed and orders placed for the line materials.

Orders were also placed for the requirements of cables and cable boxes of the Madras System.

Details regarding 688 villages programmed for electrification at an estimated cost of Rs. 401 lakhs during 1956–57 and 1957–58 were furnished to the Central Water and Power Commission to obtain the T.C.M. Aid.

The Department participated in the Park Fair Exhibition at the S.I.A.A. grounds from 24th December 1955. The Exhibition authorities have decided to give the Department a gold medal in view of the excellent show put up by the Department.

(B) *Civil Branch.*—Tenders received for the penstock, valves and meters, power-house crane and structural steel work of the power-house for the Periyar Hydro-Electric Scheme were analysed and orders placed.

The civil lay-out plan for the various sub-stations coming under the Madras Development Plan were finalised.

The camp lay-out of Kundah camp (Bokari site) was finalised. Specifications were prepared for the temporary buildings of the Kundah Hydro-Electric Scheme. The requirements of the C.G.I. sheets for the scheme have been ordered after receipt of tenders.

Collection and compilation of rainfall and run-off figures of the various basins were continued. The number of rainfall stations at the end of the quarter was 519.

Farewell Party to Sri G. Sundaram and Sri S. R. Krishnamurthy

A farewell party was arranged at 4 p.m. on 12th April 1956 to bid farewell to Sri G. Sundaram, Consulting Engineer (Electrical), and Sri S. R. Krishnamurthi, Consulting Engineer (Civil), on the occasion of their retirement from service. Sri V. P. Appadurai, Chief Engineer for Electricity, presided. There was a large gathering of 120 members of the staff at the function. Sri B. R. Somayajulu, Chief Engineer for Electricity, Andhra State, was also present on special invitation.

Sri V. P. Appadurai, Chief Engineer for Electricity, rising to speak at the end of the party, paid a warm tribute to Sri G. Sundaram for the services rendered by him to the Electricity Department from its very commencement. He described Sri G. Sundaram as the Father of the Department, which, during his period of Chief Engineership from 1944 to 1952, has grown under his guidance into a widespread grid system in South India. The Chief Engineer said he personally owed a deep debt of gratitude to Sri G. Sundaram for the very sympathetic treatment he received from Sri G. Sundaram during his own career. Regarding Sri S. R. Krishnamurthi, the Chief Engineer said, that he had shouldered a great burden on the construction side as Chief Construction Engineer (Civil), and had been responsible for the planning and execution of a good many important civil works. The Chief Engineer further said that Sri Krishnamurthi had done yeomen service on the civil side and had ably acted as Chief Engineer for Electricity on several occasions. To him the Chief Engineer said he was greatly indebted for many important decisions on civil works. In conclusion, the Chief Engineer wished long life and Godspeed to Sri G. Sundaram and Sri S. R. Krishnamurthi.

Sri G. Sundaram, on being requested to address a few words on the occasion, referred to his long connection with the Electricity Department from its very infancy. He recounted how the Department had grown from small beginnings to its present size, which was indeed a tribute to the efficiency and service of the Departmental Engineers. He added that he received excellent co-operation from all members of the staff and was particularly thankful to them for the same as he was thereby enabled to undertake electricity development in a very rapid manner. He said he should in this connection make a special mention of the high engineering standards of the Central Technical Branch and he was proud that it had proved itself to be incorruptible in its functioning, especially in the award of large contracts. Continuing he spoke warmly of the enthusiasm and drive of the present Chief Engineer for Electricity, and wished

him every success. He also wished prosperity to all members of the staff with increasing development of electricity schemes.

Sri S. R. Krishnamurthi, speaking next on request, thanked the staff for the honour done to him on that day by arranging the function. He recalled the days when he, along with Sri Sundaram worked on the Pykara Hydro-Electric Project. He was mindful of the earnest help he had received from his staff which contributed so much for the successful completion of many important civil works. He wished all prosperity to the Chief Engineer and the Department in the coming years.

Mr. Somayajulu, who was next requested to speak, paid a warm tribute to Sri G. Sundaram and Sri S. R. Krishnamurthi with whom he had long been associated prior to his becoming the Chief Engineer for Electricity of Andhra State.

Sri M. B. Kandaswami, Chief Operation Engineer (South), proposed a vote of thanks.

Sri G. Sundaram and Sri S. R. Krishnamurthi then walked down to each member of the staff and warmly shook hands.

The function then terminated.

— *The Editor.*

Technical Press.

Cable Insu

A new plastic insulating material for cables has been developed by Wandleside Cable Works, Limited, London, in which irradiated polyethylene is used. It will be sold under the trade name Irrayadoi. The material remains stable at temperatures of upwards of 200°C., and therefore cables, insulated with such material, would be capable of jointing and soldering by the conventional methods. Also while standard polythene is soluable in mineral oils, they have no effect on the irradiated material. The insulation values are slightly higher than the standard material, and power factor is slightly lower. There is a very high resistance to mechanical damage with little loss of flexibility after normal degrees of irradiation.

" *Electrical Industries Export* "
— April 1956.

Plastic Compound.

A hard-setting plastic compound has been developed to permit rapid field insulation and weatherproofing of electrical cable splices. Packaged in polyethylene container, " Thoxene Clamp-Coat " is ready to use as soon as its two separate components have been thoroughly mixed. By covering the cable splice with the activated compound and allowing the latter to harden, which takes a time of about three hours, a weatherproof, abrasion-resistant coating with high electrical insulation is obtained. Coatings up to ⅛ inch thick can be applied without dripping off. Hardening starts within minutes after coating is applied, and compound sets firm within a few hours, even if immersed in water.

" *Electrical Construction and Maintenance* "
— February 1956.

U.S.A. Turns to very H.V. Cables.

American system planning engineers are encountering mounting difficulties in obtaining rights-of-way and the necessarily extensive sites for sub-stations for overhead lines in built-up areas, and their attention turns more and more to the possibilities of underground cables and the use of higher voltages. Approximately twice as wide a right-of-way is needed for four 220 K.V. lines transmitting the same power as one 380 K.V. line. This situation has also directed the engineers' attention to a study of the high-voltage developments in U.K. and in Europe during recent years. A detailed survey of the electricity undertakings was made, and it showed that two electricity undertakings were operating 287 and 330 K.V. systems, that 22 are considering increasing their transmission voltages above 230 K.V. Five companies are considering going to 330 K.V. or higher and eight to

400 K.V. and several are considering the use of cables for these elevated voltages. The industry will certainly need underground cables for 230 K.V. and above within the next fifteen years. American manufacturers have stated that they expect to submit cables for 300–400 K.V. for field tests in four years. Although the indications at present are that long cable runs to operate above 330 K.V. will not be needed in U.S.A. for ten years, it is considered that development work should begin without delay because of the time it takes, and to ensure that when the supply industry is ready to use the cables, it will have available proved types, which can be used with confidence.

" *Distribution of Electricity* "
—November 1955.

Capacitors for increasing load on Power Transmission Lines.

The use of capacitors connected either in shunt or in series with the transmission system under consideration may provide for the additional load capacity sought and so defer the immediate need for constructing reinforcements. If the load gain made possible by introducing capacitors will meet anticipated load increases over a period long enough to ensure that the additional revenue covers the capital and maintenance costs of the capacitors, a favourable case for their use arises.

Voltage KV.	Conductor sq. in.	Resistance ohm/mile.	Reactance ohm/mile.	Maximum current carrying capacity amps.	Mega-watt for 10 miles and 10 per cent voltage drop				
					cos/ — 1·0.	cos/ — 0·9.	cos/ — 0·8.	cos/ — 0·7.	cos/ — 0·6.
	0·10	0·44	0·57	250	1·00	0·61	0·52	0·43	0·36
6·6	0·15	0·29	0·[illegible]	350	1·50	0·79	0·62	0·52	0·43
11·0	0·10	0·44	0·5	250	2·75	1·70	1·40	1·21	1·01
	0·15	0·29	0·55	350	4·15	2·18	1·72	1·44	1·18
	0·20	0·22	0·53	450	5·50	2·55	1·96	1·61	1·31
	0·10	0·44	0·57	250	24·00	15·20	12·00	10·90	9·10
33·0	0·15	0·29	0·55	350	37·50	19·70	15·50	13·00	10·70
	0·20	0·22	0·53	450	49·50	23·00	17·70	14·50	11·8)

" *Distribution of Electricity* "
—January 1956.

Erection of 275 KV Grid.

Henley's Contract Department have recently completed the construction of a 47-mile section of the C.E.A. 275 KV grid between Staythorpe and Drakelow, looping into the new power station at Castle Donnington. The lattice steel supports of the line carry two circuits, each having twin 0·4 square inch equivalent copper S.C.A. conductors. The six line conductors each consist of twin 61/0·125 steel cored aluminium conductors, earth conductor being 0·175 square inch, equivalent copper of similar material (37/0·110). Recently commissioned at 275 KV, it is the first of the C.E.A. 0·4 square inch lines of twin conductor construction to be energized at the full design voltage.

"*Distribution of Electricity*"
—January 1956.

Transformers with Aluminium Windings.

A further order by the Aluminium Company of Canada, Limited, for three 71,000 K.V.A. single-phase generator transformers has been placed with Ferranti, Limited. These units step up to 301,400 Volts and will form the second 213,000 K.V.A. bank of generator transformers supplied by the company for the Alcan Project at Kemano, British Columbia. The transformers will have aluminium windings and it is believed they will form the largest bank of transformers with aluminium windings in the world. This brings to 13 the total of transformers ordered from Ferranti for the Alcan Project with a total capacity of 648,000 K.V.A. English Electric Company of Canada is constructing an aluminium-wound 70,000 K.V.A. power transformer for the Aluminium Company of Canada, Limited, plant at Kitimat. The transformer will be the largest ever built with aluminium high and low voltage windings.

"*Light Metals Bulletin*"
—November 1955.

Pole Protection.

Wooden poles that support transmission lines along the Minnesota River, installed by a utility in the Upper Midwest, are finding protection from the threat of bush fires, in a base sheathed with aluminium sheet. These transmission lines are threatened by fire, at certain seasons of the year, because of a heavy growth of weeds in the area. A complicating factor is that pilings used to support the poles are treated with creosote and, unless protected, quickly ignite even in flash fires. Pilings are arranged three to a transmission pole and are bonded individually to the main pole. To prevent destruction by fire, the creosoted piling has been covered with aluminium. Sheets of Alcoa alloy 4 feet by 12 feet in dimension and ·032 inch in thickness, are wrapped around the piling and secured with standard nails. This combination of aluminium sheet and nails provides a lightweight, easy-to-handle covering that will give long-lasting protection.

"*Aluminium News*"
—November 1955.

Soldering Tools and Solder for Aluminium Alloys.

A soldering tool, which is easily manipulated, light and cheap and capable of being used for the flux-less soldering of aluminium with any normal solder used for this purpose, has been developed by Tiltman Langley, Limited, of Red-hill Aerodrome, Surrey. The possibilities of soldering aluminium at 250°C have also been investigated with a solder developed by the company for making corrosion-resistant joints in high-strength aluminium alloys or cold-worked aluminium without appreciably weakening the alloys being joined. The equipment used is a band tool and an electric hot plate for raising the work to the soldering temperature. The technique is to apply the solder and to brush the surface being tinned tightly with a guarded refractory brush on the tool, any of the usual cleaning techniques having been previously applied to the aluminium; no flux is used. The surfaces to be joined after tinning are placed together and a neat fillet of solder produced by sweeping through the molten solder with the refractory brush. Experience has shown that this implement, used manually or mechanically, is more universal in its application than other soldering tools for use on aluminium. It is also less damaging to the surface than other tools. The Tiltman Longley solder, which has been subjected to salt-spray and humidity tests, has shown good corrosion-resisting properties in aluminium soldered joints, good mechanical properties and also a shear strength of 2½ tons per square inch.

"*The Engineers' Digest*"
—January 1956.

Power from the D.V.C.

The Bokare Thermal Station and the Tilaiya Hydel Station went into operation early in 1953. Among the major consumers may be mentioned—the Tata Iron and Steel Company, Indian Iron and Steel Company, Burnpur, Chittaranjan Locomotive Works and the Indian Cooper Corporation, Ghatsila. Future plans include extension of the D.V.C. Transmission System to Gaya, Patna and Dalmianagar in the West and to Calcutta in the East. On the Gaya section the line has been completed up to Barhi. At Dalmianagar, a highly developed industrial area, new extensions including another cement factory, an additional paper mill and extensions to the Chemical Factory will receive power from the D.V.C. In the eastern region, the transmission lines will reach Burdwan by the end of this year. Extension from there to Calcutta will be done before the end of next year. The present supply at Calcutta will be supplemented by a substantial bloc of power early in 1957. About the same time the first electric trains of the Eastern Railway will be ready to run, propelled by D.V.C. power. Apart from aiding industrial development D.V.C. power will bring the benefits of electricity to large portion of Bihar and West Bengal. The Government of Bihar taps power at Tilaiya, Bokare and

two other places, while the West Bengal Government is taking from Pandaveswar.

(*Bhagirath*—September 1955.)

Electrical Goods Industries in India.

Electrical goods industries have been able to achieve considerable progress during the post-independence period as a result of marked increase in electricity consumption in the country. The progress in respect of transformers, cables and wires has been impressive. India has attained self-sufficiency in the manufacture of electric fans, as also in respect of most types of lamps. In 1947, production of electric motors was of the order of 37,000 h.p., the maximum rating being 30 h.p. and it is expected that during the current year, the production will be of the order of 250,000 h.p. an increase of nearly seven times. Manufacture of larger motors also is being undertaken, the largest motor produced so far being 225 h.p. In the case of transformers also, very substantial progress has been achieved, the production and largest ratings in 1947 being 30,800 K.V.A. and 250 K.V.A./11 K.V. respectively. It is expected that in 1955, the production of transformers would exceed 500,000 K.V.A., the maximum ratings produced at the present time being 3,000 K.V.A./33 K.V. At the present time, bare copper conductors, ACSR, all-aluminium conductors, rubber and plastic insulated cables and flexibles, varnished cambric insulated power cables and telephone cables are being manufactured in the country. Substantial increase in production has been achieved and as an instance, production of rubber and plastic insulated cables has increased from 22 million yards in 1948 to over 90 million yards expected to be produced in 1955. The present production of electric fans is of the order of 300,000 numbers per annum. Production of incandescent filament lamps has increased from 7·62 millions in 1947 to about 24 million numbers expected to be produced in 1955. Present production of fluorescent lamps is of the order of 800,000 numbers per annum. Production of radio receivers is expected to increase to 70,000 in 1955 from 8,000 in 1947. Manufacturers are also producing low-priced sets costing Rs. 150 to Rs. 175 to the consumers. This has created an enlarged domestic market and increased export possibilities. Production of house service meters is expected to be about 230,000 in 1955 compared to the production of 34,000 in 1952.

"*Journal of Industry and Trade*"

—November 1955.

Madhya Pradesh Power Schemes.

A number of important power schemes have been put forward by the Madhya Pradesh State Government for inclusion in the Second Five-Year Plan. These include, addition of 30,000 K.W. at Kaperkheda Station, new 30,000 K.W. station at Akola; 20,000 K.W. at Katni Power Station; 40,000 K.W. for Korba Central Thermal Power Station, with 132 K.V., and

11 K.V. transmission lines; the Tawa Hydro-Electric Scheme of 30,000 K.W.; a 66 K.V. transmission line and extensions of 132 K.V. and 66 K.V. lines; the Arpa Hydro-electric Schemes; and Rural Electrification Schemes in more than 100 areas.

"*Electrical Industries Export*"
—October 1955.

Progress in Power Transmission.

A series of developments led to the high electricity performance of to-day's insulator. First came the work of Locko in developing the wet-porcelain process of Hewiett and Buck in inventing the clevis suspension unit, and of Austin and of Ohio Brass with the Cap and Pin unit. There followed Austin's work on treated sanded surface and the resilient pin to give flexibility in the steel-cement-porcelain combination. Since about 1906 insulators have ceased to be a barrier to advances in transmission, but a great deal of work has been carried out in the interval by manufacturers and utility organizations. Investigations have covered frequency, amplitude character, time, rate of rise, current and voltage of lightning. Remedial devices have been developed including ground wires, counterpoises, expulsion tubes, and ultra-rapid reclosure as well as many other improvements in apparatus. The 25-milion K.V.A. 330 K.V. breakers installed on the American Gas and Electric Company and Ohio Valley Electric Corporation Systems, to-day, are capable of carrying a current of 2,000 amperes, circuit opening in three cycles, and reclosing in 15 cycles after the initiation of a fault. Starting with selective time-delay relays, there followed numerous balanced schemes for duplicate lines, reverse power schemes and, when need for speed became apparent, instantaneous over-current schemes. Ohio power adapted the idea of using carrier for comparison of direction of power flow by conventional relays. By this step, relay time was brought down first to three cycles, and later to one cycle; this paved the way for the ultra-rapid reclosure of lines up to 330 K.V. in a matter of 15 cycles from initiation of fault. The success of carrier in communication led to its use in telemetering and in control. Large inter-connected networks gave rise to arrangements for sleet melting by utilizing the voltage of the system for connecting sufficient line in series to give a proper impedance to connect between the system voltage and ground. This means of melting sleet on the 132 K.V. system of American Gas and Electric has been used since 1938. One of the great additional steps in fighting ice has been the system of detection of sleet formation by measuring the drop off in carrier signal strength received over a transmission line as sleet begins to form on it. This work, originally carried out by Landon and Marquis, has been perfected over the years and is used now on many systems. An even more significant step had occurred in 1928, when the first two hydrogen cooled synchornous condensers were installed, one by New England Power at Pawtucket, and the other by Appalachian Electric Power at Turner Sub-station.

"*Electrical Engineering*"
—October 1955.

Damage to Insulators in Formosa.

The insulators examined were those used on a 150 K.V. transmission line. The damage experienced consisted of high leakage currents, flash-overs and punctures following deliquescence of salty dust carried by monsoons. The damage occurred in suspension and semi-strain strings but not to strain strings. Oil-cup insulators and pin fog-type insulators with two deep slots in them have proved satisfactory on durability tests. The conclusions reached were (1) increasing the number of insulators slightly has no effect; (2) cleaning the insulators is effective but expensive; (3) strained-string; oil-cup and fog-type insulators are satisfactory; (4) ceramic of thermal-shock quality is desirable; (5) to combat a salty atmosphere, the use of a separated and simplified transmission system is of value; and the selection of a non-lightning and non-salty route may be preferable for a future scheme.

" *Electrical Engineering Abstracts* "—October 1955.

352 MVA. Generating Unit.

With maximum steam conditions of any unit now in service or even in late stages of construction standing at about 2,400 pounds, 1,100 degrees, westinghouse and Combustion Engineering have begun work on a generating unit to carry the following eye-opening numbers; inlet steam pressure, 5,000 pounds, temperature, 1,200 degrees F; Kilowatts to the bus, 275,000. Showing its progressiveness is the Philadelphia Electric Company, which has purchased this record-breaking generating unit. The generator is rated 352,000 K.V.A., 0·85 power factor utilizing inner-cooled rotor and stator conductors. It will be self-ventilated with hydrogen at 45 psi. Construction of this large 3,600 rpm. generator is made possible by Westinghouse development of hydrogen inner-cooling in 1950. Generator-field excitation will be provided by an external motor-generator unit. The boiler, by Combustion Engineering, will be drumless, of the once-through, forced-circulation twin-furnace type.

" *Westinghouse Engineer* "
—January 1955.

Aluminium Insulated Conductors in 1954.

The use of aluminium for the conductor and the sheath of insulated cable has continued to receive attention. A progress report of a major investigation indicated the feasibility of replacing copper conductors with aluminium for high-voltage pipe-typed cable applications in so far as dielectric strength, carrying capacity, cyclic movement in service, etc., are concerned and provided some promising approaches, but not necessarily the final answer, to the problem of the connectability of aluminium. Plans for the procurement of the first press to be installed in the United States for the direct extrusion of aluminium sheath to the core of an insulated cable were announced. A new high in underground transmission voltage for North America was achieved on the Canadian Kemano-

Kitimat Project with the installation of two 301 K.V. insulated cable circuits of the low-pressure oil-filled type. The cable for one of these installations was provided with an aluminium conductor and an aluminium sheath, the latter having been applied by the "draw-down" method. Preliminary study and consideration has been given during the year to the possible need for laboratory and field trial research projects of insulated cable in the 400 K.V. range. A single conductor "solid" type paper-lead submarine cable, 60 miles in length and operating on a 100 K.V. D.C. system with water return, was placed in service during the year between the Swedish mainland and island of Gotland. Four single conductor "solid" type 69 K.V. paper-lead submarine cables, each about 30 miles in length, were installed during the summer of 1954 across the St. Lawrence River. Previous submarine installations at such voltages have not exceeded a fraction of these lengths. Prototype tests on other long submarine installations for even higher voltages were in progress throughout the year.

"*Electrical Engineering*"

—January 1955.

Transmission Trends in 1954.

Progress continued in the development of extra-high-voltage transmission. During the year there were placed in actual operation 156 miles of double-circuit 330 K.V. line on the Ohio Valley Electric Corporation (OVEC) System, supplying the Atomic Energy Commission plant at Portsmouth, and 12 miles on the adjoining American Gas and Electric (A.G. & E.) system. An additional 235 miles now under construction will bring OVEC's 330 K.V. transmission to some 390 double-circuit miles; while approximately 500 miles of 330 K.V. mostly single circuit on double-circuit towers, are authorized and in various stages of construction on the A.G. & E. system. Experience to date with radio influence under actual operating conditions has been on the whole satisfactory.

"*Electrical Engineering*"

—January 1955.

World's First Transocean Telephone Cable.

Early this summer, when the Atlantic Ocean is at its calmest, a British ship will begin to lay the first transocean telephone cable in the history of world communications. The 2,300 mile long cable will link Europe and North America. There are already a number of cables across the floor of the Atlantic ocean, but they carry telegraphic communications only. The new transocean telephone cable, the laying of which is expected to be completed in mid-1956, is an enormous step in world communications. The longest deep-sea telephone line now in use is only some 120 miles long.

"*The Eastern Metals Review*"

—April 1955.

Social and Personal.

Sri K. M. Kuruvilla, Chief Electrical Inspector to Government, retired from service on 25th June 1956 forenoon.

Sri L. Ekambaram, Superintending Engineer (Generation), Madras Electricity System, Madras, proceeded on leave on average pay for three months from 8th March 1956 and on expiry of leave, he was posted as Superintending Engineer (Generation), Erode.

Sri T. Krishnaswamy, Superintending Engineer, Papanasam Electricity System, Madurai, was transferred as Chief Electrical Inspector to Government, Madras.

Sri B. V. Ananda Rao, Divisional Electrical Engineer, was promoted as Superintending Engineer (Electrical) and was posted as Superintending Engineer (Generation), Madras Electricity System, Madras.

Sri G. S. Rama Iyer, Divisional Electrical Engineer, was promoted as Superintending Engineer (Electrical) and was posted as Superintending Engineer, Papanasam Electricity System, Madurai.

The following Assistant Engineers (Electrical) were promoted as Divisional Electrical Engineers:—

Sri V. Ramamurthy.
Sri R. Venkatesan.
Sri B. Kammara Menon.
Sri N. C. Kumaran.

Appreciation.

On the occasion of Sri M. B. Kandaswami, Chief Operation Engineer, relinquishing office from 22nd August 1956 afternoon the Chief Engineer for Electricity wishes to place on record his appreciation of the long, able and devoted service rendered by Sri M. B. Kandaswami to the Department. The good wishes of the Department go to him for his health and happiness.

On the occasion of Sri K. Kesava Ayyangar, Accounts Officer, Madras Electricity System, Madras, retiring from service, on 19th August 1956 forenoon, the Chief Engineer for Electricity wishes to place on record his appreciation of the able and devoted service rendered by Sri K. Kesava Ayyangar to the Department. The good wishes of the Department go to him for his health and happiness in his retirement.

Salient Features of Pykara Dam.

1	Full Reservoir Level	+ 6,799 ft.
2	Maximum Water Level	+ 6,800 ft.
3	Crest of Spillway	+ 6,781·5 ft.
4	Length of Spillway	321·5 ft.
5	Top of Dam	+ 6,804 ft.
6	Width of Dam at Top	18 ft.
7	Lowest Foundation Level	+ 6,629 ft.
8	Length of Dam at Top	645 ft.
9	Height of Dam	175 ft.
10	Centre of Scour Pipe	+ 6,696 ft.
11	Diameter of Scour Pipe	6 ft.
12	Centre of Power Pipe	+ 6,710 ft.
13	Diameter of Power Pipe	6 ft.
14	Total quantity of Masonry	5·3 m. cft.
15	Total quantity of Earthfilling	5·3 m. cft.
16	Free Catchment area	29·3 sq. miles
17	Combined Catchment area	38·1 sq. miles.
18	Bottom Width at Deepest Portion	125 ft.
19	Maximum water spread	48·2 m. sq. ft.
20	Maximum Surplusing Capacity	31,000 Cusecs.
21	Capacity of Reservoir	2,000 m. cft.
22	Approximate Cost	Rs. 1,40,78,600.

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